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## AREOGRAPHY.

BY PERCIVAL LOWELL.

*(Read April 4, 1902.)*

1. Facts familiar to the specialist are often credited with a general appreciation they do not possess. Immersed in his own line of research, the investigator forgets that others are not as intimate as he with some of the fundamental points of his inquiry, and omits as truisms what to others are not even known for truths. Areography is such a subject. Probably no one outside of the pursuit is aware how cogent is the conclusion to be derived from an inspection of the maps that have been made of the planet, as to the reality and the relation of the markings there depicted. Nor was it indeed till after I had compared these maps with some particularity that certain deductions from them forced themselves upon me. It will perhaps, therefore, not be unproductive of result if I present at this general meeting a collective view of the maps which have from time to time been made of Mars and note what they imply. Maps speak best for themselves, and with very slight introduction can be made to tell their own story better than any amount of text.

2. Of the maps here brought together, the earlier are taken from Flammarion's thesaurus *La Planète Mars*, Proctor's Dawes' map from his own book, Schiaparelli's from his memoirs in the *Accademia dei Lincei*, and the later ones from my own work. Of these latter, that for 1896-97 is the result of my own synthesis of the Flagstaff and Mexican observations of the Lowell Observatory for those years, while the ones for 1898-99 and 1900-01 I have but just completed, and they appear here for the first time.

3. All the maps here given marked in their day the point that areography had then reached. With but two exceptions, that of Flammarion and Proctor, therefore, they represent original observations made by the maker of the map himself or under his direction, and show in procession the evolutionary development of the subject. Such maps as failed to add to existing knowledge and are valuable merely as confirmatory documents have not been included. On the other hand, no map which materially contributed anything has been left out. Many excellent charts, therefore, have had to be omitted, not always because they presented nothing new, but

because contemporaneous ones included practically all their discoveries with additions. Of these, Cerulli's maps of 1896-97 and 1898-99 and Flammarion's of 1900-01 deserve special mention. The omitted maps confirm, not invalidate, the conclusions here drawn.

4. Twelve maps constitute the series. Of these the ordering chronologically runs thus :

I.	Map of Beer and Mädler . . . . .	1840
II.	Map of Kaiser . . . . .	1864
III.	Map of Dawes, by Proctor . . . . .	1867
IV.	Map résumé by Flammarion . . . . .	1876
V.	Map of Schiaparelli . . . . .	1877
VI.	Map of " . . . . .	1879
VII.	Map of " . . . . .	1881-82
VIII.	Map of " . . . . .	1883-84
IX.	Map of Lowell . . . . .	1894
X.	Map of " . . . . .	1896-97
XI.	Map of " . . . . .	1898-99
XII.	Map of " . . . . .	1900-01

Mercator's projection is used in all the maps. The zero meridian is in the same point on the planet in all except Kaiser's, though that meridian does not always fall on the same part of the plate, being in I, IX, X, XI and XII on the extreme left, in III, IV, V, VI, VII and VIII in the centre. Beer and Mädler's map is given by Flammarion on a stereographic projection which, for the sake of inclusion in the present series from its age and chronological importance, has been changed to Mercator's. All other circumpolar projections have been omitted.

5. It will be seen from inspection of the maps, and would be simply corroborated by further additions to the list, that increase in our knowledge of the surface of Mars falls naturally into four divisions or stages of development. The first of these is pre-cartographic ; the second extends from 1840 to 1877; the third from 1877 to 1892; the fourth from 1892 to the present day. The first three of these divisions correspond to those given in Flammarion's *La Planète Mars*. The fourth is since the publication of that book.

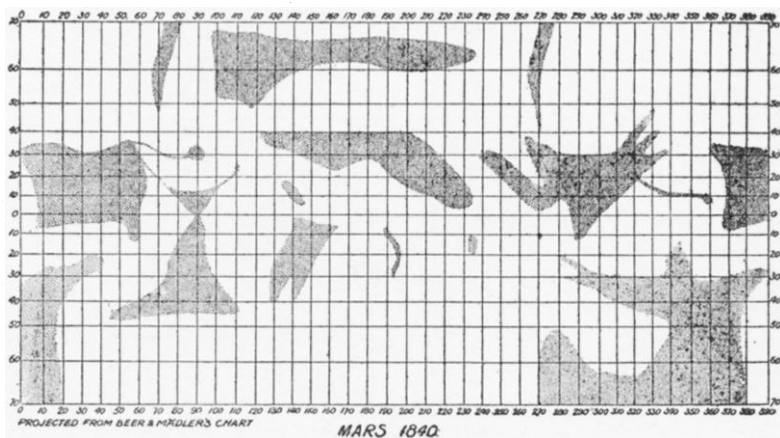
6. Near the end of the several periods are observations which mark the dawn of the next to come, making as they do adumbration of phenomena clearly to be revealed in the succeeding stage. Though not themselves the detection of details which characterize

the period, they make transition to them. Dawes thus made twilight to the third period in 1864; W. H. Pickering and the Lick observers to the fourth in 1892.

7. Distinct phenomena characterize the three periods. Patches of light and shade make the markings shown on the maps of the first stage of cartography. Of a piece though these patches are, their shapes appear well defined. At first one might suppose such to be due to the handicraft of the draughtsman and to possess no scientific value. But inspection of the several charts, one after the other, shows that the shapes are not artistic embodiments of ill-seen shadings, but are intrinsic traits of the shadings themselves, for chart after chart reproduces the same turns and twistings.

8. To see this we have but to take up in sequence the maps from 1840 to 1876. No. 1 of the series shows a cordon of patches

FIG. 1.

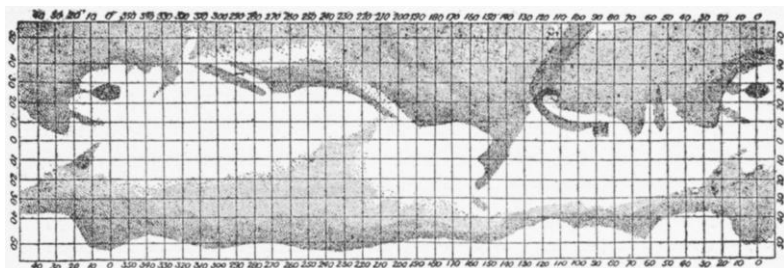


Map of Beer and Mädler, 1840.

stretching round the map at about  $30^\circ$  south latitude. Their height is greatest at  $90^\circ$  of longitude, and from this slopes down through  $360^\circ$  to  $20^\circ$  longitude, whence it gradually rises to the maximum. At the point of maximum is an oval marked out by broad shading on the south, by narrow penciling on the north, and holding a roundish dark spot in its centre. This is the Solis Lacus, the eye of Mars. To the right of it follows a leech-like patch, the Mare Sirenum and the Mare Cimmerium seen as one. After this comes

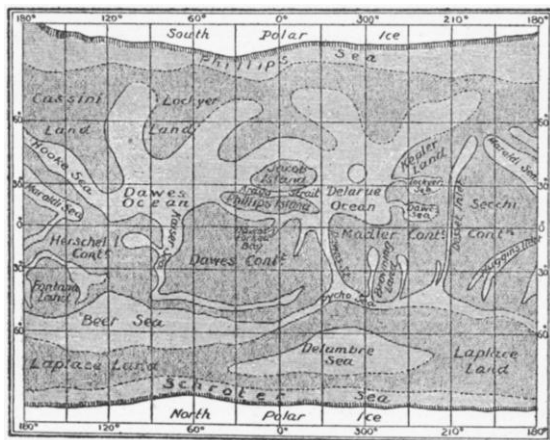
a large dark area in the shape of a funnel, the Syrtis Major. Then a ribbon ending in a scroll, the Sabaeus Sinus, the adopted zero point of Martian longitudes.

FIG. 2.



Map of Kaiser, 1864.

FIG. 3.

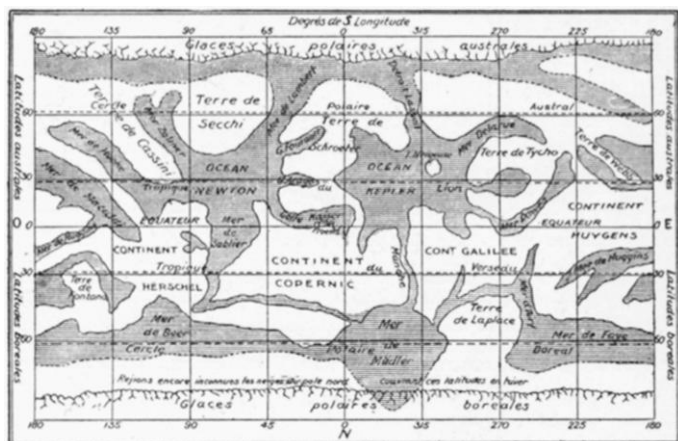


Map of Dawes, by Proctor, 1867.

9. In map No. 2, Kaiser's, all these features can be followed, from the eye with its eyebrow and the curve of its lower lid down through the chain of seas back to the oculus again. The various other dark markings on the map can be similarly identified.

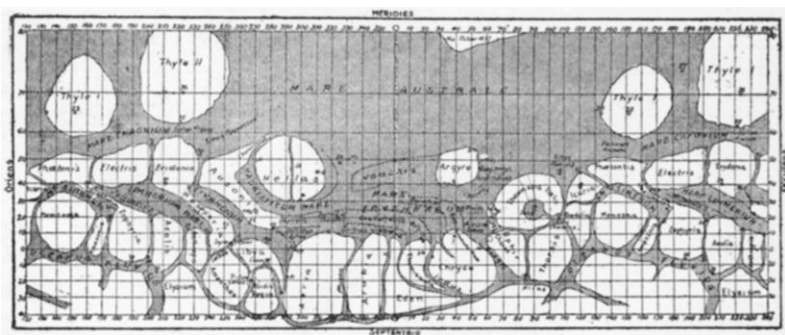
10. A very different set of phenomena stamps the advance made in the second period. Over the bright portions of the map is now drawn a network of fine lines. The dark patches remain as before. These singular lines are what are known as the "canals" of Mars.

FIG. 4.



Map résumé, by Flammarion, 1876.

FIG. 5.

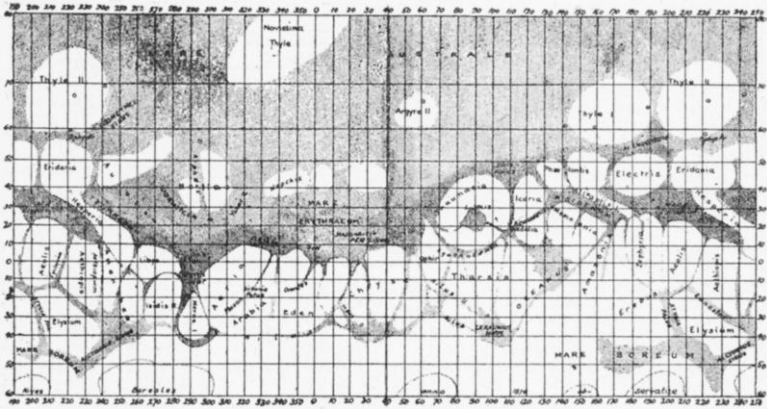


Map of Schiaparelli, 1877.

II. The second period was the work of Schiaparelli. Of it are here given four maps, all that he made on Mercator's projection.

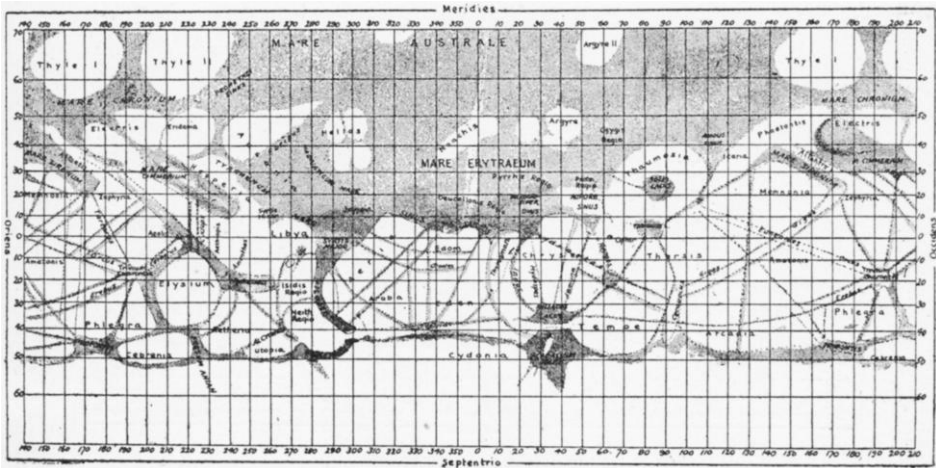
After the opposition of 1883-84 he drew only maps with the pole for centre, because of the tilt of the Martian axis which exposed the northern regions and hid the southern ones.

FIG. 6.



Map of Schiaparelli, 1879.

FIG. 7.



Map of Schiaparelli, 1881-1882.

The distinctive features of these maps are the "canals." The



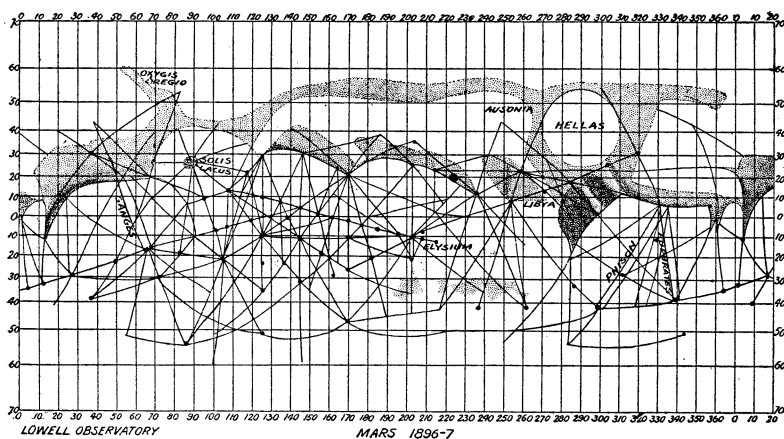


is of their essence. But the observations necessary to its appreciation are not easy. Probably even to-day not above a dozen persons have seen the canals well enough to make their opinion on the subject of weight, but all who have done so agree in their dictum.

12. As with the first and second periods, so with the second and third there was a transition state between the two. What Dawes had done for the first gap, W. H. Pickering and the Lick observers did for the second. In 1892, at Arequipa, Pickering found irregularly narrow markings in the midst of the then called seas, and the Lick observers detected "streaks" in the same regions. These played much the same part, though in the case of the Lick observers much more, to subsequent work that the Dawes' markings had to Schiaparelli's, so far as "canal" detection is concerned.

13. For in 1894 Mr. Douglass at Flagstaff found that the irreg-

FIG. 10.

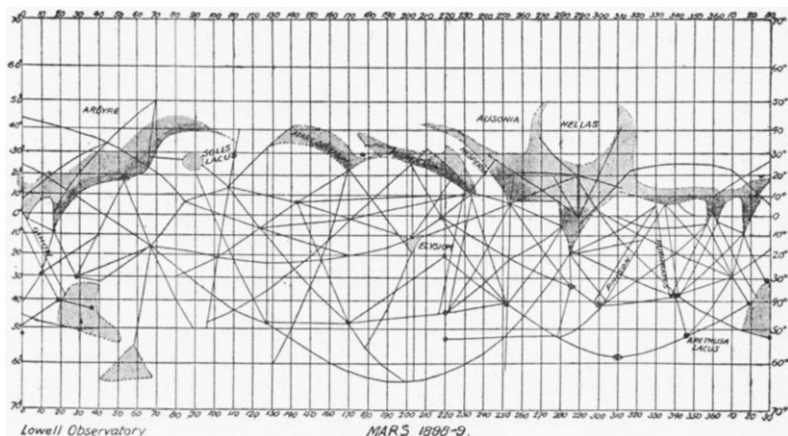


Map of Lowell, 1896-97.

ular lines of Pickering and the streaks of the Lick observers were foreshadowings of something much more peculiar. He found that a system of lines of the startlingly regular character which gives to the "canals" their technical interest, overspread the whole of the great southern dark areas. Thus the third period marks the detection of "canals" in the dark regions, and from that a complete change in the character of the seas, already in part so ably detected by Pickering. Furthermore, the network of each system showed

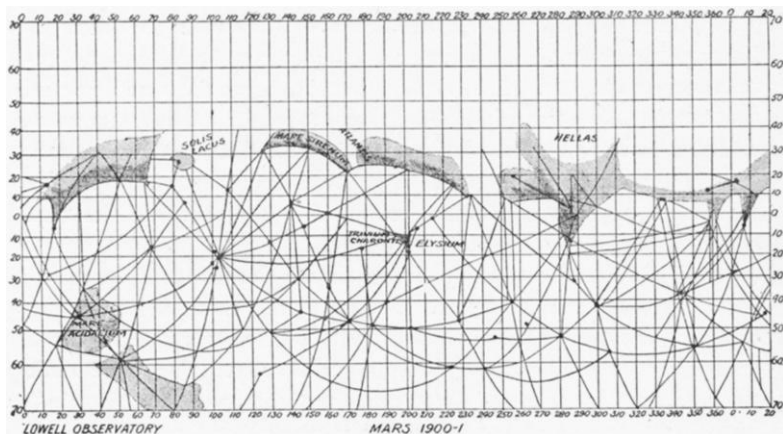
itself to be knotted with spots at its intersections. Many of the spots in the bright regions were detected by Pickering in 1892. Lastly, the two systems turned out to be connected together, the

FIG. 11.



Map of Lowell, 1898-99.

FIG. 12.



Map of Lowell, 1900-1901.

one system running into the other and marked by nick-like points in the coast line, thus making one united mesh of lines and knots superposed over the whole surface of the planet.

14. The history of areography may be thus summed up :  
1840-1876. Period of detection of large dark and light markings on the surface of the planet.  
1877-1892. Period of detection of "canals" in the bright regions.  
1892-1902. Period of detection of "canals" in the dark areas.

15. Three deductions follow an inspection of the whole series of maps :

I. The fundamental agreement of the series.

This is evident at once, but can perhaps be made more so by placing the later maps at a greater distance from the eye, upon which the fainter markings take on the look they would wear were the planet less well seen.

16. II. Evidence that the regularity of the "canals" was not due to predisposition on Schiaparelli's part, but was forced upon him by the objects themselves.

Comparing his own maps on the subject, it appears that an evolution took place in his perceptions. His first map, that of 1877, represents the "canals" as straits, more or less irregular, running up into the land. His next, made in 1879, depicts them narrower, straighter and decidedly more peculiar. That of 1881-82 shows them as fully developed geometrical designs, a character they never afterward lose.

Now, the fact that his representations of the canals grew in regularity as time went on, proves such character to have been no imputation on his part. Had he imagined it, he would have depicted the canals so to start with. As it was, increasing familiarity compelled him to recognize features which he had at first consciously or unconsciously ignored. We have here, indeed, a record left by himself of his own conversion to belief in the very qualities that make the canals so difficult of credence.

17. III. Evidence of an evolution in the detection of the markings from simple to complex. A steady progression in the matter of detail can be traced from its beginning to its end. And the progression is in increasing order of difficulty. The large dark patches are the easiest of detection, the Schiaparellian "canals" in the bright regions the next so, the "canals" in the dark regions the hardest. This is conclusively shown by the number of times each class was seen in the many drawings made at Flagstaff. It is here also evidenced by the way each map, while adding to, also corroborates its predecessor.